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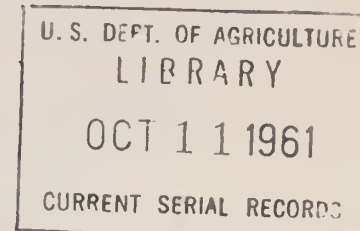
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Studies on the Annual Variation in Blood Ketone Bodies 1/

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A study was initiated in the Fall of 1957 to study the variation of blood ketone bodies with lactation, dry period and with the effects of feeding rations with and without silage. The results of this initial study were indeterminate primarily because of an inordinately large environmental effect that caused the cows to vary up and down together over time irrespective of their physiological status or ration.

As a consequence a second study was inaugurated on six cows to study this relationship between the cows. The level of total blood ketone bodies was determined at 10-day intervals by the Behre salicylaldehyde procedure (1) over a period of 18 months.

A graph of the average of the \log_{10} of the ketone concentrations is shown over a 12-month period in Figure 1. It may be seen that there was a considerable rise in ketone bodies during the winter and that several smaller peaks occurred in Spring and Summer. Horrocks and Paterson (2) have reported similar data from cows in England; they did not relate the ketone level to temperature, however. The present study correlates air temperature for the Fall and Winter seasons and maximum water temperature for the Spring and Summer with blood ketone levels and provides circumstantial evidence for an influence of cold and heat stress on levels of blood ketone bodies.

For statistical purposes the ketone concentrations were converted into logarithms in order to overcome the highly skewed nature of the raw data. The ketone concentrations ranged from 0.8 to 28.0 mg % with the median 2.70 mg % and the arithmetic mean 3.50 mg %. The log values provided a nearly normal distribution of the ketone data, and were used for an analysis of variance and correlations with temperature.

1/ Paper presented at the Annual Meeting of the American Dairy Science Association, June 19-22, 1960 at Utah State University, Logan, Utah.

A simple analysis of variance, provided in Table 1, shows that the differences between cows are significant, and the differences over time highly significant. While conditions of feeding and physiological

Table 1
Analysis of Variance

	df	s ²	Mean square	F
Between days	47	120157.5	2556.5	6.97**
Between cows	5	4543.5	908.7	2.48*
Error	235	86232.5	366.9	

status of the cows probably have an effect on the concentration of blood ketone bodies, by far the largest factor would seem to be environmental. The environmental effect may contain variation due to feeding due to the cows being on some of the same rations over time. However, when the data on individual cows were examined, there was an indication that, for example, the feeding of silage does not have as much effect as might be thought. Cows in winter on rations without silage closely paralleled those receiving it. There is a suggestion of a tendency for cows to be higher in ketone body concentration during the first 60 days of lactation than at other times, but this tendency is by no means consistent.

To follow up the lead of the possible effect of temperature on ketone body level, the data for all cows were divided into two groups in order to study the effects of cold and heat. All of the data between the dates of October 1 and April 1 were grouped together and correlated with minimum daily temperature, while the data obtained between April 1 and October 1 were grouped together and correlated with maximum water temperature. Each of these data groups includes data from two different years. It appeared in Figure 1 that the effect of both cold and heat stress was to increase blood ketone bodies. Therefore, it might be expected that minimum Winter temperature would give negative correlations with ketone bodies and high Summer temperatures, positive correlations. A number of correlations have been calculated on the data for individual cows. The effect of minimum Winter temperature is given in Table 2. There are significant relationships in five or six cows. The correlations with temperatures on days previous to the taking of blood samples show that there is a lag of two to three days between temperature and level of ketone bodies.

For the warm weather periods, water temperature seemed to give better relationships with ketone body level than air temperature. The water temperature is affected by air movement and humidity and for these reasons may give a better estimate of heat stress. Correlations of maximum daily water temperature^(a) with ketone body level are significant in four of six cows. A similar lag of two to four days exists between temperature and

(a) Water temperature of an open tank five feet in diameter and containing 70-80 gallons of water.

response in level of ketone bodies. It may be noted that in the cows on which the effect of temperature is non-significant the correlations nevertheless show the same trends as the other cows.

It would appear that the effect of cold on ketone body level begins when the air temperature drops below 35° F., and the effects of heat are consistent with the view that air temperatures above 85° F. place stress on cows and this may be accentuated by high humidities. The data are suggestive of conditioning effects. In Figure 1 the cows do not respond so markedly to the second cold spell as they do to the first.

The mechanism of the effect of cold or heat on ketone body level is not known. It might be speculated that the effect of cold is to increase body metabolism to keep the body warm, and that the mobilization of body fat and perhaps greater feed intake may account for the increased ketone levels. In hot weather another explanation must be found. Perhaps a decrease in feed intake on hot days may cause blood ketones to rise because of a mild fasting condition. Aside from all this there remains the possibility blood ketone level and fat catabolism is controlled by hormones. The relationship of the data presented here and the disorders called ketosis is obscure. But it must be pointed out that the study of the fat metabolism of normal dairy cows is not without value in the elucidation of this problem. The study of normal levels of ketone bodies in cows has been ignored for a long time.

References

1. Behre, J. A. J. Biol. Chem. 136: 25, 1940.
2. Horrocks, D. and J. Y. F. Paterson. J. Comp. Path. Therap. 67: 331, 1957.

Table 2
Correlations of minimum daily air temperature with
blood ketone bodies during fall and winter

Days previous to sample taking	Cow Numbers					
	853	854	857	864	909	1059
25 degrees of freedom						
1	-0.16	-0.29	-0.43*	-0.65**	-0.39*	-0.01
2	-0.35	-0.46*	-0.52**	-0.80**	-0.56**	-0.35
3	-0.39*	-0.47*	-0.33	-0.91**	-0.22	-0.32
4	-0.27	-0.33	-0.22	-0.59**	-0.08	+0.01
5	-0.03	-0.11	0.00	-0.12	0.00	+0.28

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

Table 3
Correlations of maximum daily water temperature with
blood ketone bodies during spring and summer

Days previous to sample taking	Cow Numbers					
	853	854	857	864	909	1059
21 degrees of freedom						
1	+0.44*	-0.18	+0.31	+0.05	-0.12	-0.15
2	+0.71**	+0.26	+0.46*	+0.36	-0.09	-0.11
3	+0.68**	+0.48*	+0.39	+0.51*	+0.17	+0.08
4	+0.47*	+0.26	+0.33	+0.33	+0.32	+0.26
5	+0.20	+0.06	+0.28	+0.22	+0.31	+0.18

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

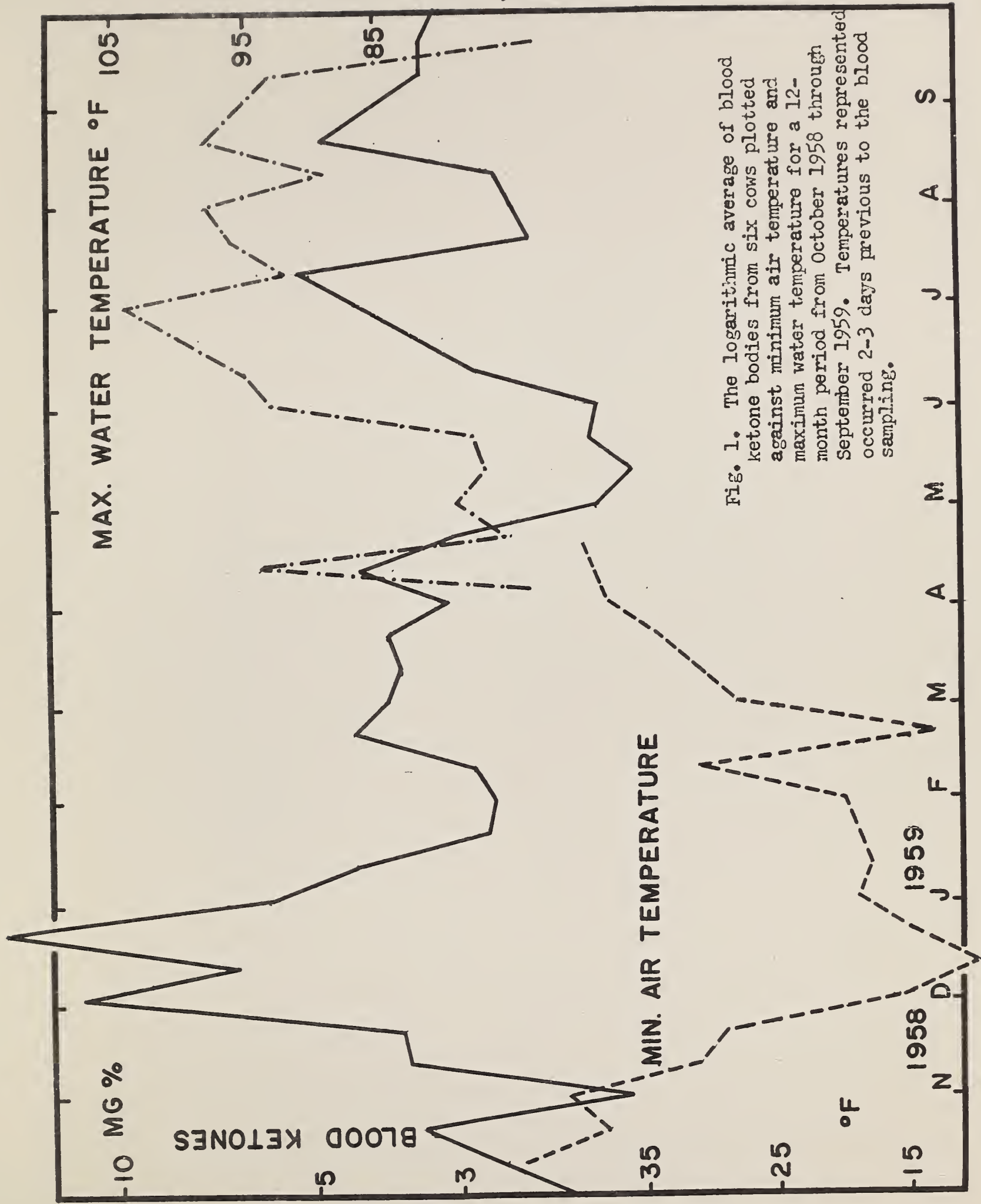


Fig. 1. The logarithmic average of blood ketone bodies from six cows plotted against minimum air temperature and maximum water temperature for a 12-month period from October 1958 through September 1959. Temperatures represented occurred 2-3 days previous to the blood sampling.

